Saskatchewan
Environment

Water Pollution
Control Branch

# Insecticide Residues in Surface Waters of Agricultural Areas in Saskatchewan Summer 1985

January 1986
WPC 70

# INSECTICIDE RESIDUES IN SURFACE WATERS OF AGRICULTURAL AREAS IN SASKATCHEWAN SUMMER 1985

S. A. Ferris
Water Pollution Control Branch
Saskatchewan Environment

December, 1985

WPC 70

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| LIST OF TABLES | | ii |
| SUMMARY | | 1 |
| 1. INTRODUCTION | | 3 |
| | 1.1 Objectives | 3 |
| 2. BACKGROUND | | 4 |
| | 2.1 Insect Pests | 4 |
| | 2.1.1 Grasshoppers | 4 |
| | 2.1.2 Orange Blossom Wheat Midge | 4 |
| | 2.2 Insect Control | 5 |
| 3. WATER QUALITY SURVEILLANCE ACTIVITIES | | 7 |
| | 3.1 Participants | 7 |
| | 3.2 Water Quality Sampling Locations, Timing and Parameters | 7 |
| | 3.2.1 Grasshopper Insecticide Monitoring Program | 7 |
| | 3.2.2 Wheat Midge Insecticide Monitoring Program | 11 |
| | 3.3 Field and Laboratory Methods | 11 |
| 4. RESULTS AND DISCUSSIONS | | 14 |
| 5. ACKNOWLEDGEMENTS | | 18 |
| 6. REFERENCES | | 19 |

LIST OF TABLES


| | | Page |
|---|---|---|
| Table 1 | Grasshopper Insecticide Monitoring Locations and Collection Dates | 9 |
| Table 2 | Chemical Use and Duration of Application by Rural Municipality | 10 |
| Table 3 | Wheat Midge Insecticide Monitoring Locations and Collection Dates | 12 |
| Table 4 | Analytical Methodology for Target Insecticides | 13 |
| Table 5 | Results of Insecticide Analysis - Chemicals Used for Grasshopper Control | 15 |
| Table 6 | Results of Insecticide Analysis - Chemicals Used for Wheat Midge Control | 16 |

## SUMMARY

Significant economic losses due to insect infestations are not uncommon in Saskatchewan. Annual losses due to grasshoppers range from $5 million to $40 million in Saskatchewan. In 1983, the wheat midge was responsible for yield reductions in the northeast sector of the province valued at more than $30 million.

During the spring and summer of 1985 the Water Pollution Control Branch of Saskatchewan Environment in co-operation with the Water Quality Branch, Inland Waters Directorate of Environment Canada undertook a study of the fate of insecticide residues in surface waters. Specifically, the study sought to quantify the residues present in surface waters of those chemicals used to control the recent grasshopper and wheat midge outbreaks.

After consultation with agricultural representatives, samples were collected during July for grasshopper insecticide residue analysis from sites on Wascana Creek, Wood River, Thompson Reservoir and Notukeu Creek. Analysis for Furadan (Carbofuran), Sevin (Carbaryl), Dimethoate, Lorsban (Chlorpyrifos) and Malathion were performed on the samples collected for the grasshopper insecticide monitoring program. Samples were also collected during July from the Assiniboine River, Carrot River, Whitefox River and Melfort Creek for the wheat midge insecticide monitoring program. These samples were analysed for Lorsban (Chlorpyrifos) and Furadan (Carbofuran).

# 1. INTRODUCTION

This year the grasshopper plague experienced in the majority of agricultural areas in Saskatchewan and the wheat midge infestations in the northeast sector resulted in a 5 to 6 fold increase in chemical use for the control of these pests. In anticipation of the expected insecticide use combined with a desire to ensure the continuing integrity of surface waters important for a multitude of uses, a study of the fate of the residues of these chemicals in surface waters was deemed necessary.

## 1.1 Objectives

The general objective of this project was to monitor the fate of insecticide residues in surface waters within southern Saskatchewan. Specifically, the study sought to quantify the residuals present in surface waters of those chemicals used to control the outbreaks of grasshoppers and wheat midge during the spring and summer of 1985.

## 2. BACKGROUND

### 2.1 Insect Pests

#### 2.1.1 Grasshoppers

Grasshoppers are a major pest of cultivated crops and rangeland grasses of the world's semi-arid regions. Particularly susceptible are areas receiving less than 750 mm of precipitation in the form of rain or snow. Since much of Saskatchewan lies within this area, agricultural producers in this province are subject to a recurring threat of crop loss due to this insect (Harris, 1985).

Severe to very severe infestations were predicted by the Saskatchewan Grasshopper forecast for 1985. The areas of greatest infestation were generally south of a line from North Battleford to Kamsack. Annual losses of cereal grains due to grasshoppers in Saskatchewan range from $5 million to over $40 million. Moderate infestations of grasshoppers can consume between 16 and 60 percent of available forage.

#### 2.1.2 Orange Wheat Blossom Midge

The Orange Wheat Blossom Midge is a widespread pest of many cereal grains and other grasses. Wheat is the preferred host plant. The grain kernel is the

only part of the plant damaged by wheat midge. Wheat midge infestations tend to be most severe in the northeast portion of Saskatchewan. In 1983, the wheat midge was responsible for yield reductions in the northeastern portion of the province valued at more than $30 million. (Harris et al, 1985b)

## 2.2 Insect Control

Methods of insect control are somewhat dependant on the habits of the insect pest concerned, types of crops, severity of infestation and the economic importance of the crop.

Cultural control methods for grasshoppers and wheat midge include early seeding, crop rotation, tillage, burning trash and trap strips. Cultural control methods must be considered as a preventative approach to insect control. Biological control and weather are other factors which are important to insect control.

When insect control by cultural, biological methods or climatic factors prove unsatisfactory chemical control is often necessary to reduce populations to economically acceptable levels.

The severe grasshopper infestations predicted for southern

Saskatchewan during the 1985 growing season materialized as expected. Multiple chemical applications were necessary in some areas due to the heavy infestations and multiple hatches. The chemicals used, in descending order of relative amounts used, for grasshopper control this season included: Furadan (Carbofuran), Sevin (Carbaryl), Decis (Deltamethrin), Dimethoate, Lorsban (Chlorpyrifos) and Malathion.

Effective chemical control of wheat midge can only be achieved over a 6 to 10 day period when the plant is between the stage of 1/2 head emergence to 1/2 flowering (Harris et al, 1985b). As a result of the stage of crop development it is often necessary to perform chemical applications for wheat midge control by aerial spraying. Chemicals commonly used in Saskatchewan for the control of wheat midge are Lorsban (Chlorpyrifos) and Furadan (Carbofuran).

## 3. WATER QUALITY SURVEILLANCE ACTIVITIES

### 3.1 Participants

This study was a co-operative program conducted by the Water Pollution Control Branch of Saskatchewan Environment and the Water Quality Branch, Inland Waters Directorate of Environment Canada. Both organizations contributed to the study, planning and analytical costs on an equal basis. The water quality monitoring and report preparation were completed by Saskatchewan Environment.

### 3.2 Water Quality Sampling Locations, Timing and Parameters

#### 3.2.1 Grasshopper Insecticides Monitoring Program

Several drainage basins were considered for the grasshopper insecticide monitoring program however the Wascana Creek, Wood River and Notukeu Creek basins were selected due to the proximity to high infestation areas and continuing flow. In the event of significant rainfall contingency plans called for the collection of additional samples due to the possibility of runoff liberated residues entering the streams. Table 1 summarizes the grasshopper insecticide monitoring program sample locations and collection dates. Agricultural representatives were contacted to ascertain the chemicals used and a suitable post-application monitoring date for each area. Table 2 summarizes the chemicals used and

approximate duration of application for rural municipalities in the selected monitoring areas. Analysis for Carbofuran (Furadan), Carbaryl (Sevin), Dimethoate, Chlorpyrifos (Lorsban) and Malathion were performed on samples collected for the grasshopper insecticide monitoring program. Analysis for Deltamethrin (Decis) could not be performed since a laboratory capable of completing the test could not be found.

TABLE 1

Grasshopper Insecticide Monitoring Locations and Collection Dates

| Sample Station | Collection Date |
|---|---|
| Wascana Creek near Richardson | July 3, 1985<br>August 15, 1985<br>(rainfall event) |
| Wood River near Courval | July 4, 1985 |
| Wood River at #45 Highway | July 4, 1985 |
| Thompson Lake opposite Gravelbourg WTP intake | July 4, 1985 |
| Notukeu Creek at #43 Highway | July 4, 1985 |
| Notukeu Creek at #19 Highway (Blank Sample) | July 4, 1985 |

TABLE 1

Grasshopper Insecticide Monitoring Locations and Collection Dates

| Sample Station | Collection Date |
|---|---|
| Wascana Creek near Richardson | July 3, 1985<br>August 15, 1985<br>(rainfall event) |
| Wood River near Courval | July 4, 1985 |
| Wood River at #45 Highway | July 4, 1985 |
| Thompson Lake opposite Gravelbourg WTP intake | July 4, 1985 |
| Notukeu Creek at #43 Highway | July 4, 1985 |
| Notukeu Creek at #19 Highway (Blank Sample) | July 4, 1985 |

TABLE 2

Chemical Use and Duration of Application by Rural Municipality

| Rural Municipality | Chemicals Used | Watershed |
|---|---|---|
| 103 (Sutton)<br>June to July 1 | Sevin XLR (Carbaryl)<br>Furadan (Carbofuran)<br>Malathion | Wood River |
| 104 (Gravelbourg)<br>June to July 15 | Sevin XLR<br>Furadan | Wood River,<br>Thompson Lake |
| 105 (Glen Bain)<br>June to July 15 | Sevin XLR<br>Furadan<br>Decis (Deltamethrin) | Notukeu Creek |
| 106 (Whiska Creek)<br>June to July 8 | Decis<br>Sevin XLR<br>Hopper Stopper<br>(Dimethoate) | Notukeu Creek |
| 107 (Lac Pelletier)<br>June to July 15 | Sevin XLR<br>Furadan<br>Decis | Notukeu Creek |
| 127 (Francis)<br>June 20 and later | unspecified | Wascana Creek |
| 128 (Lajord)<br>June 20 and later | unspecified | Wascana Creek |
| 133 (Rodgers)<br>June | Sevin XLR<br>Furadan | Wood River |
| 134 (Shamrock)<br>June to July 15 | Hopper Stopper<br>Sevin XLR<br>Furadan<br>Decis | Wood River |

### 3.2.2 Wheat Midge Insecticide Monitoring Program

Selection of the sampling sites and dates for the wheat midge monitoring program were made after consultation with Saskatchewan Agriculture officials since a regular forecast is not issued for these pests. The general area of concern was the northeast sector of the province where wheat midge infestations have historically been most severe. Table 3 summarizes the wheat midge insecticide monitoring program sampling locations and collection dates. Analysis for Carbofuran (Furadan) and Chlorpyrifos (Lorsban) were performed on samples collected for the wheat midge monitoring program.

## 3.3 Field and Laboratory Methods

Water samples for both monitoring programs were collected manually in specially prepared 1000 ml bottles provided by Environment Canada. Samples were preserved in 0.1% $H_2SO_4$ solution and transported on ice. Two blanks were submitted, one for each monitoring program, to assure bottle cleanliness and proper collection techniques.

All analyses for this study were contracted to Enviro-Test Laboratories in Edmonton, Alberta. Table 4 summarizes the methodology employed for the analysis of these samples. Additionally, a quality control program including spikes and blanks was performed for 10% of the samples submitted.

TABLE 3

Wheat Midge Insecticide Monitoring Locations and Collection Dates

| Sample Station | Collection Date |
|---|---|
| Assiniboine River at Sturgis Weir | July 23, 1985 |
| Assiniboine River at Kamsack WTP Reservoir | July 23, 1985 |
| Carrot River at #6 Highway | July 23, 1985 |
| Carrot River at #23 Highway | July 23, 1985 |
| Whitefox River at #6 Highway | July 23, 1985 |
| Whitefox River at #55 Highway | July 23, 1985 |
| Melfort Creek at Melfort WTP Reservoir | July 23, 1985 |
| Melfort Creek Below Dam (Blank) | July 23, 1985 |

TABLE 4

Analytical Methodology for Target Insecticides

| Pesticide | Extraction Method | Detection Method |
|---|---|---|
| 1. Carbofuran | Methylene Chloride | GC/NPD (nitrogen/phosphorus) or HPLC - dansyl derivative - Fluorescence or UV detection with GC/MS confirmation when necessary |
| 2. Carbaryl (Sevin) | Methylene Chloride | GC/NPD (nitrogen/phorphorus) or HPLC - dansyl derivative - Fluorescence or UV detection with GC/MS confirmation when necessary |
| 3. Dimethoate | Methylene Chloride | GC/NPD, with GC/MS confirmation when necessary |
| 4. Malathion | Methylene Chloride | GC/NPD, with GC/MS confirmation when necessary |
| 5. Chlorpyrifos (Lorsban) | Methylene Chloride | GC/ECD, electron capture detector with GC/MS confirmation when necessary |

GC - gas chromatography

HPLC - high pressure liquid chromatography

MS - mass spectrometry

NPD - nitrogen phosphorous detection

## Results and Discussions

The results of the grasshopper and wheat midge insecticide monitoring programs are presented in Tables 5 and 6 respectively.

The only insecticide detected in the study was Dimethoate. Dimethoate was present at concentrations of 0.2 ug/L at Wood River near Courval and 0.3 ug/L at Wood River at #43 Highway (Table 5). Although the concentrations of Dimethoate reported were less than the actual detection level of the analytical method, a semi-quantitive result was reported. The presence of Dimethoate at trace levels was confirmed by GC/MS (gas chromotograph/mass spectrometry) methods. The analysis of the blank samples indicates that collection procedures were adequate.

The ADI (allowable daily intake) for Dimethoate in man is 0.02 mg/Kg of bodyweight (University of Saskatchewan, Toxicology Research Centre, 1985). For a 70 Kg man this value converts to a ADI of 1.4 mg. Assuming a 2 litre per day consumption and 20% of the ADI (Canada Drinking Water Quality Guidelines, 1978) the maximum acceptable level (MAL) for Dimethoate in drinking water is 140 ug/L (ppb). Using the World Health Organization (1984) 1% of ADI value a similar calculation yields a MAL of 7 ug/L for Dimethoate. The Saskatchewan Surface Water Quality Objectives recommend the concentration of any pesticide not exceed 1/100 of the 48 hour Thm (median tolerance limit) to ensure reasonable protection of aquatic life and other uses (Saskatchewan Environment 1983). Thm's for fish have been reported to range from 5 to 14 ppm (Toxicology Research Centre, 1985). The concentrations of

TABLE 5

Results of Insecticide Analysis - Chemicals Used for Grasshopper Control

| Location | Date | Carbofuran | | Carbaryl | | Dimethoate | | Chlorpyrifos | | Malathion | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Results (ppb) | Detection Limit (ppb) | Results (ppb) | Detection Limit (ppb) | Results (ppb) | Detection Limit (ppb) | Results (ppb) | Detection Limit (ppb) | Results (ppb) | Detection Limit (ppb) |
| Wascana Creek near Richardson | July 3/85 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 |
| | August 15/85 (duplicate 1) | ND | 0.5 | ND | 0.5 | ND | 0.05 | ND | 0.05 | ND | 0.05 |
| | August 15/85 (duplicate 2) | ND | 0.5 | ND | 0.5 | ND | 0.05 | ND | 0.05 | ND | 0.05 |
| Wood River near Courval | July 4/85 | ND | 0.5 | ND | 0.5 | 0.2 | 0.5 | ND | 0.5 | ND | 0.5 |
| Wood River at #43 Highway | July 4/85 | ND | 0.5 | ND | 0.5 | 0.3 | 0.5 | ND | 0.5 | ND | 0.5 |
| Thompson Lake at Gravelbourg WTP Intake | July 4/85 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 |
| Notukeu Creek at #43 Highway | July 4/85 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 |
| Blank Sample (labelled Notukeu Creek at #19 Highway) | July 4/85 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 | ND | 0.5 |

ND = Not detectable
ppb = parts per billion (ug/L)

TABLE 6

Results of Insecticide Analysis - Chemicals Used for Wheat Midge Control

| Location | Date | Carbofuran | | Chlorpyrifos | |
|---|---|---|---|---|---|
| | | Result (ppb) | Detection Limit (ppb) | Result (ppb) | Detection Limit (ppb) |
| Assiniboine River at Sturgis Weir | July 23/85 | ND | 0.5 | ND | 0.05 |
| Assiniboine River at Kamsack WTP Reservoir | July 23/85 | ND | 0.5 | ND | 0.05 |
| Carrot River at #6 Highway | July 23/85 | ND | 0.5 | ND | 0.05 |
| Carrot River at #23 Highway | July 23/85 | ND | 0.5 | ND | 0.05 |
| Whitefox River at #6 Highway | July 23/85 | ND | 0.5 | ND | 0.05 |
| Whitefox River at #55 Highway | July 23/85 | ND | 0.5 | ND | 0.05 |
| Melfort Creek at Melfort WTP Reservoir | July 23/85 | ND | 0.5 | ND | 0.05 |
| Blank Sample (labelled Melfort Creek below dam) | July 23/85 | ND | 0.5 | ND | 0.05 |

ND = not detectable

ppb = parts per billion (ug/L)

Dimethoate detected in the waters of the Wood River were less than the drinking water and surface quality guidelines listed above.

The results for the other chemical parameters indicate that the compounds were not present at detectable concentrations in the drainage basins surveyed. The lack of significant rainfall in southern Saskatchewan during the summer months low flows in small streams and low solubility may partially account for the absence of the other compounds in the surface waters surveyed. In addition, most of these insecticides have a short half-life in alkaline waters (pH greater than 8.0); a characteristic common to all the water bodies sampled. Other factors which could affect the results include the timing and location of insecticide applications in each stream basin. These factors were not assessed in this study. The solubility of Dimethoate (25 g/L at 21$^{o}$C) and a 8 week half-life (river water) may partially account for the presence of this substance in two of the water samples.

In the event of another outbreak, consideration should be given to more intensive sampling over smaller areas to determine if surface water quality is affected for short time periods. Other sampling procedures (e.g. collection and extraction of larger volumes of water) could also be used to enhance the capability to detect insecticides in surface waters.

The significance of Deltamethrin (Decis) use on surface waters could not be assessed due to the lack of analytical capability.

## 5. ACKNOWLEDGEMENTS

The assistance of R. G. Ruggles - Saskatchewan Environment, D. J. Gregor - Environment Canada and J. L. Harris - Saskatchewan Agriculture in the completion of this study is gratefully acknowledged.

## 6. REFERENCES

Department of National Health and Welfare. 1979. Guidelines for Canadian Drinking Water Quality 1978. Federal-Provincial Working Group on Drinking Water. Canadian Government Publishing Centre, Hull, Quebec, 76 pages.

Harris, J. L. 1985(a). Grasshopper Control. Saskatchewan Agriculture, Regina, Saskatchewan. 18 pages.

Harris, J. L., Harvey, D. A., Doane, J. F., and Elliott, R. H. 1985(b). Orange Blossom Wheat Midge. Saskatchewan Agriculture - Agriculture Canada, Regina, Saskatchewan. Informational Bulletin, 2 pages.

Saskatchewan Environment, 1983. Water Quality Objectives (Sept. 1983 edition). Regina, Saskatchewan.

Toxicology Research Centre, 1985. Ecotoxicology of Grasshopper Control Products: A Briefing. University of Saskatchewan, Saskatoon. June 13, 1985.

World Health Organization. 1984. Guidelines for Drinking - Water Quality Volume 1 Recommendations. World Health Organization, Geneva. 130 pages.